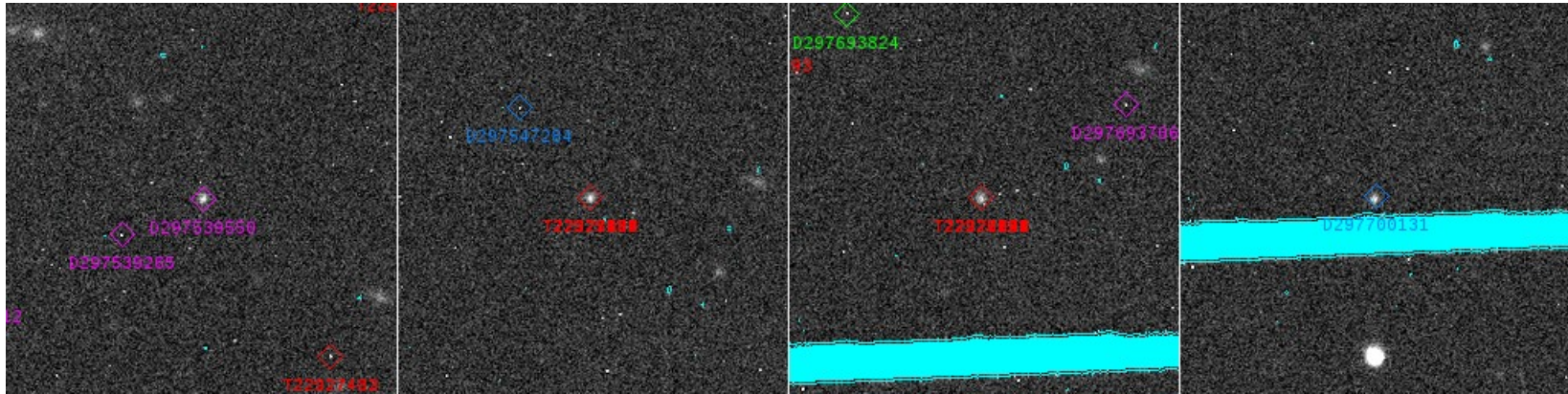# NEOs in the Isolated Tracklet File

Robert Weryk[1,*], Richard Wainscoat[1], and Peter Vereš[2]

(1) Institute for Astronomy, University of Hawaii, Honolulu HI, USA
(2) Harvard & Smithsonian, Minor Planet Center, Cambridge MA, USA
(*) Physics and Astronomy, The University of Western Ontario, London ON, Canada

Introduction

- Survey telescopes are very dependent on follow-up, but …
  - The majority of tracklets do not post to the NEOCP
  - Initial orbit estimates might have too large uncertainty
  - Objects become too faint or weather is not ideal
- Unlinked data are relegated to the Isolated Tracklet File (ITF)
  - Rich repository for data mining, some data 20+ years old
  - Includes 'was not confirmed' NEOCP objects
  - Often easier to link tracklets versus a visual search of probable ephemeris locations in precovery images
 - May contain single night tracklets for second oppositions

The Isolated Tracklet File (ITF)

- ~10 million detections with ~3 million unique tracklet names
- Recent linking activities has noticeably reduced its size

site	code	count	percent
Pan-STARRS 1, Haleakala	F51	4 995 424	47.7 %
Mt. Lemmon Survey	G96	2 826 063	27.0 %
Steward Observatory, Kitt Peak-Spacewatch	691	510 410	4.9 %
Catalina Sky Survey	703	253 295	2.4 %
Pan-STARRS 2, Haleakala	F52	235 829	2.3 %
Palomar Mountain/NEAT	644	108 068	1.0 %
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Previous Linking Effort

- We previously reported (PDC 2017) on linking non-NEOs
  - Since then, >~160 000 objects and >20 000 identifications
  - Goal to stop 'known' objects from posting to the NEOCP
  - Massive help for PS survey review -> batch submissions
  - Required a lot of time to be merged at MPC
- Also reported (PDC 2019) on linking a small number of NEOs
  - More computationally intensive due to motion changes
  - Shrinking ITF makes search more computationally feasible
  - Required a lot of manual checking for mislinkages
  - From older tracklet data, no means of added follow-up
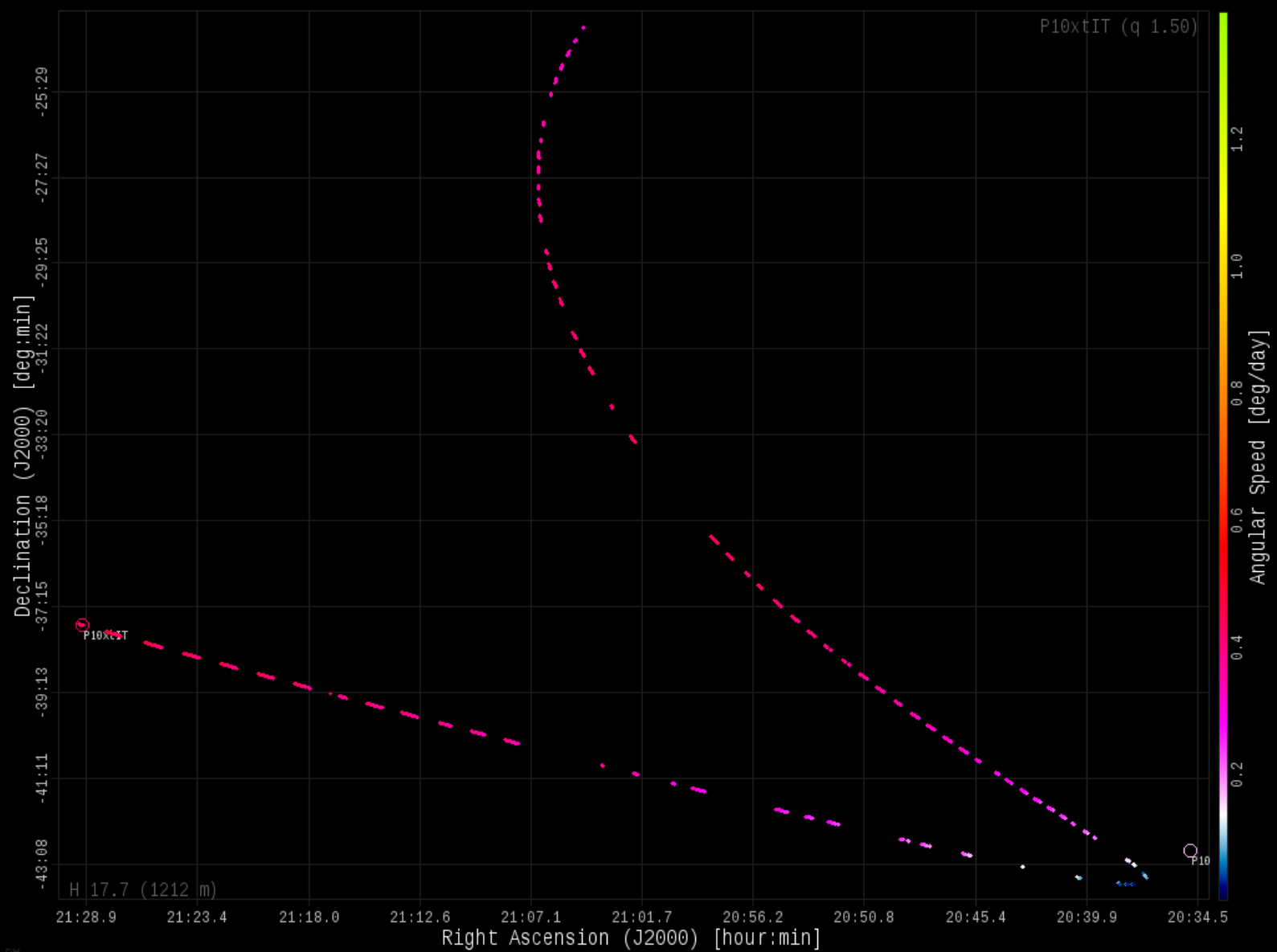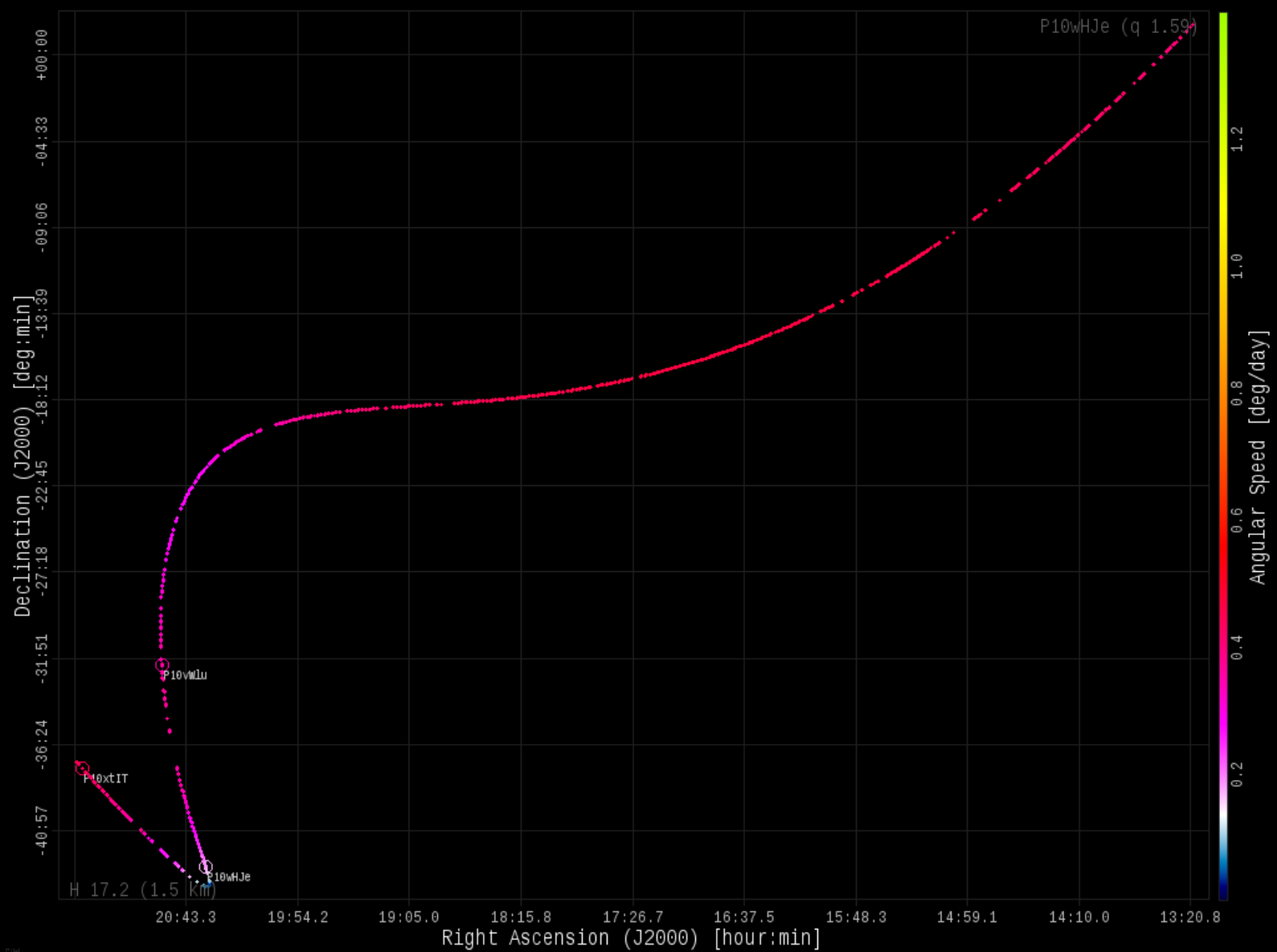
Want to 'automagically' find NEOs

- Recent work has made our search method more efficient
  - Turned into an 'ITF autolinker' tool, with daily ITF retrieval
  - Allows finding low 'digest score' NEOs without the NEOCP
  - Submit linkages of most recent objects to the 'ID pipeline' at the MPC, meaning they are processed immediately
- Some improvements still to be made
  - Currently need at least five tracklets for single opposition
  - NEOs are not automatically submitted, nor are distant objects such as JFC like orbits or even perhaps Centaurs
  - Could submit them after more reliable residual checks

Apophis (part of IAWN campaign)

- Useful test : find Apophis in the (at the time) recent ITF
  - Motivated by IAWN campaign to study Apophis passage
  - Surveys submitted apophis tracklets as unknown candidates
- Major weakness in our existing method was search time
  - During dark time, processing could take over a week
  - Apophis 'officially found' by us on Dec 28, after C51 posted
  - So we restricted initial tracklet tests to those with score >=6 which means processing now completes on same day
- MPC has since made all V<19 objects post regardless of score
  - But V>19 still require a search tool like ours

Recent new NEOs from the ITF

- >=3 tracklet candidates are checked/verified each day
  - But can also test single tracklets for being recoveries
  - As the ITF shrinks further, we can relax the search criteria
- Dedicated MPECs (not DOUs) now sent for ITF designations

object	H	q [AU]	Arc [days]	notes
2021 AB8	19.9	1.15	123	450 metre NEO
2021 AF8	20.1	0.98	2327	400 metre PHA, pre-recovered
2021 ES5	21.7	0.88	4043	200 metre PHA, but is 2010 FF10
2017 FS188	18.7	1.29	1486	800 metre 'NEO' found as 2-opp

Progress is on-going

- It seems far fewer known objects now post to the NEOCP
  - Follow-up better spent on more worthy objects
- Only a handful of NEOs have been linked so far
  - It's not very surprising, the NEOCP works well
  - Balance between how much manual review is required, certainly two tracklet cases could be looked at
  - Could also process lower SNR detection catalogues
- We continue to link 'boring' and 'sporadic' tracklets
  - Total minor planet count recently passed one million
  - One day, everything remaining will be interesting!